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**APPLICATION  
FOR  
UNITED STATES  
LETTERS PATENT**

**APPLICANT:** Takahashi et al.  
**FOR:** SAW FILTER DEVICE AND  
PACKAGE FOR ACCOMMODATING  
THE SAME  
**DOCKET NO.:** 2000-P342686

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SAW FILTER DEVICE AND PACKAGE FOR ACCOMMODATING THE SAME  
BACKGROUND OF THE INVENTION

This application claims benefit of Japanese Patent Application No. 2000-342686 filed on November 9, 2000,  
5 the contents of which are incorporated by the reference.

The present invention relates to elastic surface wave filter devices used for optical communication systems and mobile radio communication systems and packages for accommodating elastic surface wave filters.

10 Elastic surface wave (hereinafter referred to as SAW) filters have such features as small size, high stability, high accuracy, high reliability and freedom from adjustment, and find extensive applications as functional devices for controlling high-frequency  
15 signals. As an example, SAW filters are used as frequency selectors, filter devices, resonators, delay elements and functional devices.

SAW filters control electric high-frequency signals via elastic surface waves propagated along a  
20 substrate surface. As the substrate used is usually made of such piezoelectric materials as liquid crystal LBO, lithium tantalate ( $\text{LiTaO}_3$ ) and lithium niobate ( $\text{LiNbO}_3$ ). Substrates made of piezoelectric material is hereinafter referred to as chip substrate. Fig. 12 shows an SAW  
25 filter having a plurality of interdigital transducers (IDTs) 11 to 14, which are formed on a chip substrate 10 by using a thin film forming technique or a lithographic technique.

The SAW filter has a pair of interdigital

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transducers or a plurality of pairs of interdigital transducers juxtaposed in the direction of progress of elastic surface wave. In the example shown in Fig. 12, two pairs of interdigital transducers are provided. In  
5 surface wave propagation path as a region with the interdigital transducers 11 to 14 provided therein, the SAW filter converts an elastic surface wave to an electric high frequency signal or converts an electric high frequency signal to an elastic surface wave and selects  
10 a frequency dependent on the line width of the interdigital transducers 11 to 14.

The SAW is usually used in a state accommodated in a package. An SAW filter in the state accommodated in a package is hereinafter referred to as SAW filter device.  
15 The interdigital transducers 11 to 14 are connected by bonding wires or the like to input or output signal electrode terminals provided on the package accommodating the SAW filter. In the SAW filter shown in Fig. 12, the interdigital transducers 11 and 14, for  
20 instance, are connected as an input and an output signal electrode to an input and an output signal electrode terminal, respectively. Also, the interdigital transducers 12 and 13 are connected as grounding electrodes to grounding electrode terminals.

25 Since the piezoelectric material has pyroelectricity, when the SAW filter device experiences a sudden temperature change in such ambient circumstances as when it is reflow soldered to mount it in a printed circuit board or the like or when its thermal

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shock test is done, it is subject to polarization and generation of charge on the surface of the chip substrate 10. Such charge generated on the surface of the chip substrate 10 generates an electric field in the  
5 interdigital transducers. When the electric field generated in a portion subject to utmost charge concentration reaches the electric breakdown level, electric discharge is caused among the interdigital transducers and, in the extreme case, destruction of the  
10 interdigital transducers due to the electric discharge occurs.

To prevent the electric discharge among the interdigital transducers, a ceramic package 91, as shown in Fig. 13, is used to accommodate the SAW filter. The  
15 package has a metal film 92 formed by plating or deposition on its inner bottom surface. More specifically, the ceramic package 91 used for accommodating the SAW filter 100 is such that the bottom surface of the chip substrate of the SAW filter 100 is  
20 in contact with the metal film 92 when the SAW filter 100 is accommodated. Thus, the grounding electrodes of the SAW filter are electrically connected to the metal film 92. In this package, charge generated, if any, due to polarization can escape to the metal film 92, thus  
25 preventing the destruction of the interdigital transducers 11 to 14.

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A plastic package may be used to reduce the cost of the SAW filter. However, it is difficult to form a metal film by plating or deposition on the plastic package.

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5 That is, it is difficult to provide, on the package, a means for permitting escape of charge generated due to polarization. It is therefore inevitable, as shown in Fig. 14, packaging of the SAW filter without presence of any metal film between plastic package 7 and SAW filter 100. In order that the plastic package 7 can be used, it is important that the structure of the chip substrate of the SAW filter 100 is free from polarization or capable of permitting escape of charge generated due to

10 polarization.

SUMMARY OF THE INVENTION

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15 An object of the present invention, accordingly, is to provide an SAW filter device, which has a structure capable of preventing destruction of the interdigital transducers by charge generated on the chip substrate due to polarization in such case as when mounting the SAW filter on substrate or when testing the same.

Another object of the present invention is to provide a package for accommodating an SAW filter, which

20 is a plastic package and, nevertheless, is capable of permitting escape of charge generated due to polarization.

An SAW filter device with a chip substrate of a piezoelectric material having a plurality of

25 interdigital transducers and accommodated in a plastic package according to the present invention, wherein a common potential means for providing a common potential in the interdigital transducers, a charge neutralizing means for neutralizing charge generated on the chip

substrate due to polarization, or a charge escape means  
for causing escape of charge generated on the chip  
substrate due to polarization, is provided as an electric  
discharge preventing means for preventing electric  
5 discharge among  
the plurality of interdigital transducers on the chip  
substrate.

With the electric discharge preventing means  
provided on the chip substrate, it is possible, without  
10 provision of any measure for preventing electric  
discharge on the package side, to permit neutralization  
or escape of charge generated due to polarization in such  
case as when mounting the SAW filter on substrate or when  
testing the SAW filter device. This permits  
15 accommodation of the SAW filter in the plastic package.  
That is, it is possible even in the case of using a plastic  
package to prevent destruction of the interdigital  
transducers due to charge generated by polarization.

A package for accommodating an SAW filter in the  
20 inside according to the present invention, which  
comprises a terminal member made of a metal extending  
out of the package and extending into the package such  
as to form an L-shaped portion. Thus, it is possible to  
accommodate the SAW filter in the package such that the  
25 bottom surface of the chip substrate is in contact with  
the metal plate portion. Charge generated due to  
polarization thus is not concentrated on the side of the  
SAW filter chip substrate surface but is neutralized.  
This means that such status as charge concentration on

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particular portions of the interdigital transducers can be avoided. Consequently, it is possible to prevent electric discharge among the interdigital transducers.

SAW filter device according to a preferable embodiment has a SAW filter having the electric discharge preventing means formed on the chip substrate and accommodated in the above package. Since the bottom surface of the chip substrate is in contact with the metal plate portion, charge generated due to polarization thus is not concentrated on the side of the SAW filter chip substrate surface but is neutralized, even generated.

Other objects and features will be clarified from the following description with reference to attached drawings.

#### 15 BRIEF DESCRIPTION OF THE DRAWINGS

Figs. 1(A) and 1(B) are a plan view and a sectional view taken along line B-B in Fig. 1(A) showing a first embodiment of the SAW filter according to the present invention;

20 Figs. 2(A) and 2(B) are a plan view and a sectional view taken along line B-B in Fig. 1(A) showing a second embodiment of the same filter according to the present invention;

25 Figs. 3(A) and 3(B) are a plan view and a sectional view taken along line B-B in Fig. 1(A) showing a third embodiment of the SAW filter according to the present invention;

Figs. 4(A) and 4(B) are a plan view and a sectional view taken along line B-B in Fig. 1(A) showing a fourth

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embodiment of the SAW filter according to the present invention;

5 Figs. 5(A) and 5(B) are a plan view and a sectional view taken along line B-B in Fig. 1(A) showing a fifth embodiment of the fifth embodiment of the SAW filter according to the present invention;

10 Figs. 6(A) and 6(B) are a plan view and a sectional view taken along line B-B in Fig. 1(A) showing a sixth embodiment of the SAW filter according to the present invention;

Fig. 7 is a plan view showing a portion of a seventh embodiment of the SAW filter according to the present invention;

15 Fig. 8 is a plan view showing a portion of an eighth embodiment of the SAW filter according to the present invention

20 Figs. 9(A), 9(B) and 9(C) are a plan view showing an example of package suited for accommodating the SAW filter, a plan view taken along line B-B in Fig. 1(A) and a sectional view taken along line C-C in Fig. 1(A) according to the present invention;

Fig. 10 is a plan view showing how an SAW filter 100 is accommodated in the package 7 shown in Fig. 9;

25 Fig. 11 is sectional view of the package accommodating the SAW filter by conductive adhesive;

Fig. 12 shows an SAW filter having two pairs of interdigital transducers;

Fig. 13 is a sectional view of the ceramic package accommodating the SAW filter; and



Fig. 14 is a sectional view of the plastic package accommodating the SAW filter.

#### PREFERRED EMBODIMENTS OF THE INVENTION

Preferred embodiments of the present invention  
5 will now be described with reference to the drawings.

Fig. 1(A) is a plan view showing a first embodiment of the SAW filter according to the present invention, and Fig. 1(B) is a sectional view taken along line B-B in Fig. 1(A). The first embodiment of the SAW filter has  
10 interdigital transducers 11 to 13, which are formed from an Al (aluminum) thin film or an Al alloy thin film on a chip substrate 1 of a piezoelectric material, such as lithium tantalate ( $\text{LiTaO}_3$ ), lithium niobate ( $\text{LiNbO}_3$ ), etc. A high resistivity thin film 2 providing a high electric  
15 resistance is formed such that it intervenes between the chip substrate 1 and the interdigital transducers 11 to 14.

The interdigital transducers 11 to 14 are connected by bonding wires (not shown) or the like to an input and  
20 an output signal electrode terminal and grounding electrode terminals provided on a package, which accommodates the SAW filter. For example, the interdigital transducers 13 and 12 are connected as input and output signal electrodes to the input and output  
25 signal electrode terminals, respectively. The interdigital transducers 11 and 14 are connected as the grounding electrodes to the grounding electrode terminals.

The high resistivity thin film 2 is made of a

material having a high resistance of the order of megaohms or more, such as Ti (titanium), Si (silicon), etc. It is further possible to use SiO<sub>2</sub> as the high resistivity thin film. The high resistivity thin film 2 has a  
5 thickness of the order of several hundred angstroms (i.e., of the order of 10<sup>-2</sup> micrometers).

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10 The high resistivity thin film 2 is formed by deposition or <sup>sputtering</sup> sputtering on the chip substrate 1. The interdigital transducer material <sup>is</sup> formed by, for instance, <sup>sputtering</sup> sputtering Al. Then, a photo-resist is coated, and patterned by an exposure device or the like. After the photo-resist on unnecessary portions is removed, the interdigital transducers 11 to 14 are formed. Alternatively, after forming the high resistivity thin  
15 film 2 on the chip substrate 1, a predetermined photo-resist may be provided, and then the interdigital transducer material, such as Al may be formed. The SAW filter as shown in Fig. 1 can be obtained by the above described process.

20 In the SAW filter shown in Fig. 1, the high resistivity film 2 is connected to all the interdigital transducers 11 to 14. When reflow soldering a package accommodating the above SAW filter for assembling to communication equipment or the like and when thermal  
25 <sup>shock</sup> chock testing the SAW filter, the SAW filter is subject to charge generation due to polarization brought about by a pyroelectric effect. Since the interdigital transducers 11 to 14 are held at the same potential, when charge is generated due to polarization, electric

discharge among the interdigital transducers 11 to 14 can be prevented and destruction of the interdigital transducers 11 to 14 can be prevented.

5 The high resistivity thin film 2 is formed on the surface of the chip substrate 1 of a piezoelectric material. This has an effect of neutralizing charge generated due to polarization. It is thus possible to avoid charge concentration on particular portions of the interdigital transducers 11 to 14. This also has an  
10 effect of preventing electric discharge among the interdigital transducers 11 to 14. Thus, with the high resistivity thin film 2 formed between the chip substrate 1 and the interdigital transducers 11 to 14 to have the interdigital transducers 11 to 14 at the same potential  
15 and also with the charge neutralizing action, it is to more reliably prevent the destruction of the interdigital transducers 11 to 14 by charge generated due to polarization.

Thus, with the SAW filter of the structure shown  
20 in Figs. 1(A) and 1(B) accommodated in the plastic package, it is possible, without any measure on the package side, to prevent the destruction of the interdigital transducers 11 to 14 due to the pyroelectric effect of the chip substrate <sup>1</sup>/<sub>10</sub>. In other words, the structure  
25 shown in Figs. 1(A) and 1(B) is particularly effective when using the plastic package for accommodating the SAW filter. The high resistivity thin film 2 is very thin, and thus it has only ignorable effect in the elastic surface wave.

Fig. 2(A) is a plan view showing a second embodiment of the same filter according to the present invention. Fig. 2(B) is a sectional view taken along line B-B. The second embodiment of the SAW filter, which has

5 interdigital transducers 11 to 14 formed on the chip substrate 1 of a piezoelectric material, also has a high resistivity thin film 2 formed such as to entirely cover the interdigital transducers 11 to 14 and having a high electric resistance. The material and thickness of the

10 high resistivity thin film 2 may be the same as those in the first embodiment.

As an example, after the formation of the interdigital transducers 11 to 14 on the chip substrate 1 by a <sup>sputtering</sup> sputtering technique or a photo-lithographic technique, the high resistivity thin film 2 is formed by deposition or <sup>sputtering</sup> sputtering on the back surface of the chip substrate 1. As an alternative, it is possible to form the interdigital transducers 11 to 14 on the chip substrate 1 after the formation of the high resistivity

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20 thin film 2.

Again in the SAW filter shown in Figs. 2(a) and 2(b), the high resistivity thin film 2 is in contact with all the interdigital transducers 11 to 14. The interdigital transducers <sup>11</sup> 1 to 14 thus can be held at the same potential.

25 Since the interdigital transducers 11 to 14 are at the same potential at the time of the reflow soldering or a thermal shock test, it is possible to prevent electric discharge among the interdigital transducers 11 to 14. Thus, the structure shown in Figs. 2(A) and 2(B) is

capable of preventing the destruction of the interdigital transducers 11 to 14.

Furthermore, in the SAW filter having the structure as shown in Figs. 2(A) and 2(B), the high resistivity thin film 2 is in contact with the chip substrate 1 of the piezoelectric material in a portion where the interdigital transducers 11 to 14 are not formed. It is thus possible to expect an effect of neutralizing charge generated due to polarization. Again in this embodiment, it is thus possible to avoid charge concentration on particular portions of the interdigital transducers 11 to 14.

Thus, with the SAW filter having the structure as shown in Figs. 2(A) and 2(B) accommodated in the plastic package, it is possible, without any measure in the package side, to prevent destruction of the interdigital transducer 11 to 14 due to the pyroelectric effect on the chip substrate <sup>1</sup>/<sub>10</sub>. That is, the structure shown in Figs. 2(A) and 2(B) is particularly effective in the case of using the plastic package for accommodating the SAW filter. The high resistivity thin film 2 is very thin, and its effect on elastic surface wave is ignorable.

Fig. 3(A) is a plan view showing a third embodiment of the SAW filter according to the present invention. Fig. 3(B) is a sectional view taken along line B-B in Fig. 3(A). The third embodiment of the SAW filter, which has interdigital transducers 11 to 14 on chip substrate 1 of a piezoelectric material, also has a conductive layer 3 formed on the chip substrate 1 over the entire area

of the back surface (i.e., surface opposite the surface with the interdigital transducers 11 to 14 formed thereon. The conductive material layer 3 is made of, for instance Al or Ti. Since no interdigital transducer is formed on the back surface of the chip substrate 1, it is possible to use Al or like metal as the conductive material layer 3.

With the conductive material, film 3 formed as cover film on the back surface of the chip substrate 1, it is expected that charge generated due to polarization is neutralized without being concentrated on the front surface side of the chip substrate 1. It is thus possible to avoid charge concentration on particular portions of the interdigital transducers 11 to 14. Electric discharge among the interdigital transducers 11 to 14 can be avoided.

With the SAW filter of the structure as shown in Fig. 3 accommodated in the plastic package, it is possible, without any measure on the package side, to prevent destruction of the interdigital transducers 11 to 14 due to pyroelectric effect in the chip substrate 1. Thus, the structure shown in Figs. 3(A) and 3(B) is particularly effective in the case of using the plastic package accommodating the SAW filter.

Fig. 4(A) is a plan view showing a fourth embodiment of the SAW filter according to the present invention. Fig. 4(B) is a sectional view taken along line B-B. The fourth embodiment of the SAW filter, which has interdigital transducers 11 to 14 formed on chip

substrate 1 of a piezoelectric material, also has a  
conductive material film 3, which is formed as cover film  
on the entire area of the back surface of the chip  
substrate 1 of a piezoelectric material and also has a  
5 connecting film portion for electrically connecting the  
metal film on the back surface of the chip substrate 1  
to an interdigital transducer serving as a grounding  
electrode. In the example shown in Figs. 4(A) and 4(B),  
the conductive material film portion 3 electrically  
10 connects the metal film to the interdigital transducer  
14.

With the conductive material film 3 formed as cover  
film on the back surface of the chip substrate 1 and also  
with the interdigital transducer and the conductive  
15 cover film connected to each other by the connecting film  
portion 3, it can be expected to be able to neutralize  
charge generated due to the pyroelectric effect, and also  
it is possible to permit charge generated due to  
polarization to escape via the interdigital transducer  
20 to the conductive cover film. It is thus possible to more  
effectively avoid charge concentration on particular  
portions of the interdigital transducers 11 to 14. Thus,  
electric discharge among the interdigital transducers  
11 to 14 can be more effectively prevented.

25 Thus, with the SAW filter having the structure as  
shown in Figs. 4(A) and 4(B) accommodated in the plastic  
package, it is possible, without any measure on the  
package side, to prevent the destruction of the  
interdigital patterns 11 to 14 due to pyroelectric effect

on the chip substrate <sup>1</sup>10. That is, the structure shown in Figs. 4(A) and 4(B) is particularly effective in the case of using the plastic package for accommodating the SAW filter. With the SAW filter having the structure shown in Figs. 4(A) and 4(B) accommodated in the ceramic package, it is possible to prevent the destruction of the interdigital transducers 11 to 14 without need of any measure such as formation of a metal film on the bottom surface of the ceramic package.

Fig. 5(A) is a plan view showing a fifth embodiment of the fifth embodiment of the SAW filter according to the present invention. Fig. 5(B) is a sectional view taken along line B-B. The fifth embodiment of the SAW filter, which has the interdigital patterns 11 to 14 formed on the chip substrate 1 of a piezoelectric material, also has a film 3 of a metal or like conductive material covering an edge portion of the front surface of the chip substrate 1. The conductive material film 3 does not cover the portion constituting a surface wave propagation path in the SAW filter.

With the conductive material film 3 formed on the edge portion of the front surface of the chip substrate 1, charge generated, if any, due to polarization escapes to the side of the conductive material film and does not concentrate on the portions of the interdigital transducers 11 to 14. That is, it is possible to avoid charge concentration on particular portions of the interdigital transducers 11 to 14, thus preventing electric discharge among the interdigital transducers



11 to 14. Since it is possible to avoid charge concentration on particular portions, it can be thought that the conductive material film 3 fulfills the action of neutralizing charge in the chip substrate 1.

5           Thus, with the SAW filter having the structure as shown in Fig. 5, it is possible, without any measure on the package side, to prevent destruction of the interdigital transducers 11 to 14 due to the pyroelectric effect of the chip substrate <sup>1</sup>~~10~~. In other words, the structure shown in Fig. 5 is particularly effective in the case of using the plastic package for accommodating the SAW filter. With the SAW filter of the structure shown in Fig. 5 accommodated in the ceramic package, it is possible to prevent destruction of the interdigital transducers 11 to 14 without need of such measure as forming a metal film on the bottom surface of the ceramic package.

10           Fig. 6(A) is a plan view showing a sixth embodiment of the SAW filter according to the present invention. Fig. 6(B) is a sectional view taken along line B-B. In the sixth embodiment of the SAW filter, which has interdigital transducers 11 to 14 formed on chip substrate <sup>1</sup>~~12~~ of a piezoelectric material, the interdigital transducers 11 to 14 are interconnected by thin patterns 41 having a high resistance such as Ti.

20           In the example shown in Figs. 6(A) and 6(B), a pattern 4 having a high resistance (high resistance pattern) is formed on an edge portion of the front surface of the chip substrate 1. The patterns 41 are each

connected to the high resistance pattern 4 for  
interconnecting the interdigital transducers 11 to 14.  
The high resistance pattern 4 is of the same material  
as the patterns 41. The high resistance pattern 4 does  
5 not cover the portion constituting the surface wave  
propagation path of the SAW filter. The patterns 41 have  
such a thickness as not to affect the elastic surface  
wave.

In the SAW filter shown in Figs. 6(A) and 6(B), the  
10 interdigital transducers 11 to 14 which are  
interconnected, are held at the same potential, and thus  
it is possible to prevent electric discharge among the  
interdigital transducers 11 to 14. Thus, it is possible  
to prevent destruction of the interdigital transducers  
15 11 to 14.

Thus, with the SAW filter having the structure  
shown in Figs. 6(A) and 6(B) accommodated in the plastic  
package, it is possible, without any measure on the  
package side, to prevent destruction of the interdigital  
20 transducers 11 to 14 due to pyroelectric effect on the  
chip substrate <sup>1</sup>11. That is, the structure shown in Figs.  
6(A) and 6(B) are particularly effective in the case of  
using the plastic package for accommodating the SAW  
filter. With the SAW filter having the structure as  
25 shown in Figs. 6(A) and 6(B) accommodated in the ceramic  
package, it is possible to prevent destruction of the  
interdigital transducers 11 to 14 without need of such  
measure as forming a metal film on the bottom surface  
of the ceramic package.

Fig. 7 is a plan view showing a portion of a seventh embodiment of the SAW filter according to the present invention. As shown in Fig. 7, the seventh embodiment of the SAW filter, which again has interdigital

5 transducers 11 to 14 on chip substrate 1 of a piezoelectric material, the interdigital transducers 12 and 14 each have an extension extending on the front surface of the chip substrate 1 and forming a pattern as a first pattern 51. In Fig. 7, only one of two  
10 interdigital transducers are shown.

Patterns as second patterns 52 having the same line width as the first pattern 51, are formed such that each forms a gap 53 formed between it and the first pattern 51. Dummy electrode patterns 5 are formed such that they  
15 are each connected to each pattern 5. The gaps 53 have a width (i.e., the spacing between the patterns 51 and 52 is narrower than the spacing <sup>between</sup> each of the interdigital transducer 11 and 13 and each of the interdigital transducers 12 and 14. The patterns 51 and 52 have a line  
20 width narrower than the pattern width of the interdigital transducers 11 to 14.

In the SAW filter as shown in Fig. 7, in which the gaps 53 have a width narrower than the spacing between each of the interdigital transducers 11 and 13 and each  
25 of the interdigital transducers 12 and 14, when electric discharge is generated by charge generation due to polarization of the chip substrate 1, electric discharge is generated across the gaps 53. Thus, it is possible to prevent electric discharge among the interdigital

transducers 11 to 14, thus preventing destruction thereof.

Thus, with the SAW filter of the structure as shown in Fig. 7 accommodated in the plastic package, it is possible, without any measure on the package side, to prevent destruction of the interdigital transducers 11 to 14 due to pyroelectric effect of the chip substrate <sup>1</sup>10. That is, the structure shown as in Fig. 7 is particularly effective in the case of using the plastic package for accommodating the SAW filter. With the SAW filter having the structure as shown in Fig. 7 accommodated in the ceramic package, it is possible to prevent destruction of the interdigital transducers 11 to 14, without need of such measure as forming a metal film on the bottom surface of the ceramic package.

Although electric discharge across the gaps 53 gives rise to electric noise generation, charge is generated due to polarization at the time of reflow soldering, thermal shock test, etc. and not in the duty service state of the SAW filter. Thus, the electric noise generation gives rise to no problem.

Fig. 8 is a plan view showing a portion of an eighth embodiment of the SAW filter according to the present invention. As shown in Fig. 8, in the eighth embodiment of the SAW filter, which again has interdigital transducers 11 to 14 formed on chip substrate 1 of a piezoelectric material, the interdigital transducers 11 to 14 have rounded ends and corners. Specifically, in the interdigital transducers 11 to 14, pair interdigital

transducers have rounded opposed portions 61 to 64.

Since the opposed portions 61 to 64 of the interdigital transducers are not sharp, in the event of charge generation due to polarization in the chip substrate 1, electric discharge is difficultly generated among the interdigital transducers <sup>1</sup>/<sub>1</sub>. It is thus possible to prevent electric discharge among the interdigital transducers 11 to 14, thus preventing destruction thereof.

Thus, with the SAW filter having the structure as shown in Fig. 8 accommodated in the plastic package, it is possible, without any measure on the package side, to prevent destruction of the interdigital transducers 11 to 14 due to pyroelectric effect in the chip substrate <sup>1</sup>/<sub>10</sub>. That is, the structure shown in Fig. 8 is particularly effective in the case of using the plastic package for accommodating the SAW filter. With the SAW filter shown in Fig. 8 accommodated in the ceramic package, it is possible to prevent destruction of the interdigital transducers 11 to 14 without need of forming any metal film in the bottom surface of the ceramic package.

The structures adopted in the first to eighth embodiments are capable, without any measure on the package side, of preventing destruction of the interdigital transducers 11 to 14 due to pyroelectric effect of the chip substrate <sup>1</sup>/<sub>10</sub>. However, it is possible to combine two or more structures adopted in the first to eighth embodiments. In the case of combining a plurality of structures, it is possible to reliably

prevent destruction of the interdigital transducers 11 to 14 due to pyroelectric effect.

In the structures adopted in the first to fifth embodiments, a charge neutralizing means for effecting the action of charge neutralization or charge dispersion can be realized. In the first and second embodiments 1 and 2 a common potential means is realized together with a charge neutralizing means, and in the fourth and fifth embodiments a charge escape means is realized together with the charge neutralizing means. In the structure adopted in the sixth embodiment, a common potential means is realized.

Fig. 9(A) is a plan view showing an example of package suited for accommodating the SAW filter. Fig. 9(B) is a plan view taken along line B-B. Fig. 9(C) is a sectional view taken along line C-C. In Fig. 9(C) pads 71a to 76a which are not shown in Fig. 9(C), for clarifying the connecting relation between the pads and terminals are shown. A package 7 is a one-piece plastic molding. In the example shown in Figs. 9(A) to 9(C), the package 7 has a rectangular planar shape, and has an edge wall. The package 7 further has a central rectangular recess 78 for disposing the SAW filter therein.

The package 7 has a plurality of pads 71a to 76a formed on a portion defined between the edge wall 77 and the central recess 78. The package 7 further has metal terminals 71 to 76 extending from its inside to the outside. Of the terminals 71 to 76, the terminal 74 is used as a grounding terminal (GND terminal). The pads

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71a to 76a are formed such that they are integral with the corresponding terminals 71 to 76.

The GND terminal 74 extends into the package 7, and has a longitudinally extending portion (longitudinal portion) and a laterally inwardly extending portion (lateral portion). The longitudinally extending portion and a laterally inwardly extending portion of GND terminal 74 forms an (L-shaped) metal portion 80 exposed in the recess 78 in the package 7. In the example shown in Figs. 9(A) to 9(C) only a single GND terminal 74 is provided, but it is also possible to provide a plurality of GND terminals. For example, in the case with the provision of two GND terminals, each GND terminal formed to be integral with the L-shaped portion 80 in the recess 7. In this case, the L-shaped portion 80 exposed in the recess 78 is supported in two portions, and a more stable posture of the L-shaped portion 80 can be obtained.

Fig. 10 is a plan view showing how an SAW filter 100 is accommodated in the package 7 shown in Fig. 9. When accommodating the SAW filter 100 in the package 7, the SAW filter 100 is set in the recess 78 of the package 7 such that the back surface of the chip substrate <sup>1</sup>/<sub>12</sub> is in contact with the L-shaped portion 80. Then, the interdigital transducers 11 to 14 and the predetermined pads 71a to 76a are connected to one another with bonding wires 71b to 76b. Then, the top of the package is covered with a plastic or like material.

In the package 7 shown in Figs. 9(A) to 9(C), the

L-shaped metal portion 80 is present. Also, the L-shaped portion 80 is made to be integral with the GND terminal 74. Thus, when the SAW filter 100 is accommodated in the package 7, the metal plate is in contact with the back surface of the chip substrate. This means that when the SAW filter 100 is accommodated in the package 7, a state resembling the state of the third embodiment shown in Figs. 3(B) and 3(A) is obtained. It is thus expected that charge generated by polarization is neutralized without being <sup>concentrated</sup> ~~concentration~~ in the front surface of the chip substrate of the SAW filter 100. It is thus possible to avoid charge concentration on particular portions of the interdigital transducers 11 to 14. Thus, it is possible to prevent electric discharge among the interdigital transducers 11 to 14.

Also, by connecting the GND terminal 74 on the outside of the package 7 (for instance, on a printed circuit board), it is possible to connect the GND terminal 74 and the interdigital transducer as grounding electrode to each other. With the GND terminal and the interdigital transducer connected to each other, a state resembling the state of the fourth embodiment shown in Figs. 4(A) and 4(B) is obtained. In this state, it is possible to expect neutralization of charge generated due to polarization by pyroelectric effect and also permit escape of charge generated due to polarization via the interdigital transducers to the metal film on the back surface of the chip substrate. Thus, it is possible to avoid charge concentration on particular



portions of the interdigital transducers 11 to 14.

In other words, by using the package 7 in this embodiment, it is possible to prevent destruction of the interdigital transducers 11 to 14 without any measure  
5 on the side of the SAW filter itself against charge generated due to polarization. In the case of accommodating the SAW filter provided with any of the measures in the above first to eighth embodiments in the package 7 shown in Fig. 7, it is possible to more reliably  
10 prevent destruction of the interdigital transducers 11 to 14. The SAW filter device, in which the SAW filter in any of the first to eight embodiments in the package 7 shown in Figs. 9(A) to 9(C), has improved durability against destruction of the interdigital transducers 11  
15 to 14.

In the package 7 shown in Figs. 9(A) to 9(C), the (L-shaped) metal plate portion 80 is made to be integral with the GND terminal. The L-shaped metal portion 80 thus can be formed by providing a V-shaped metal film  
20 as the GND terminal 74 when forming the terminals 71 to 76 on the package 7. That is, the L-shaped portion 80 can be formed concurrently with the formation of the terminals 71 to 76. Thus, the process of forming the package 7 is not complicated. It is thus possible to  
25 adopt the structure shown in Figs. 9(A) to 9(C). In this case, the manufacturing process can be simplified compared to the case of forming the metal film 92 by plating or deposition on the inner bottom surface of the package.

As shown in Fig. 11, when accommodating the SAW filter 100 in the package 7 shown in Figs. 9(A) to 9(C), the SAW filter 100 may be secured by conductive adhesive 81 to the package 7. As shown in Fig. 11, since the L-shaped metal portion 80 is located between the SAW filter 100 and the package 7, when the SAW filter 100 is secured by the conductive adhesive to the SAW filter 100, it is possible to obtain firmer connection between the SAW filter 100 and the L-shaped portion 80. It is thus possible to obtain more reliable electric connection between the SAW filter 100 and the L-shaped metal portion 80.

As has been shown, in the first to eighth embodiments, the chip substrate 1 itself of the SAW filter has a structure permitting neutralization or escape of charge generated due to polarization. Thus, with this filter accommodated in the plastic package, it is possible to prevent destruction of the interdigital transducers 11 to 14 irrespective of sudden temperature changes in ambient environment. In other words, in the SAW filter package in which the SAW filter of the structure of any of the embodiments 1 to 8, is accommodated in the plastic package, it is possible to prevent destruction of the interdigital transducers 11 to 14 irrespective of sudden temperature changes. It is thus possible to accommodate the chip structure 1 of the structure of any of the first to eighth embodiments in the plastic package.

In the ninth and tenth embodiments, when

accommodating the SAW filter in the package 7, it is possible to form a metal portion in contact with the back surface of the chip substrate without use of plating or deposition. Thus, by using any one of the packages 7 shown in Figs. 9 and 10, it is possible to prevent destruction of the interdigital transducers 11 to 14 without provision of any measure against charge generated due to polarization on the side of the SAW filter itself. That is, with the accommodation, in the package 7, of an SAW filter with the provision of the measure as described in connection with any of the first to eighth embodiments, it is possible to prevent destruction of the interdigital transducers 11 to 14 in the event of a sudden change in the ambient environment.

As has been described in the foregoing, the SAW filter device according to the invention has a structure in which the chip substrate itself is provided in the electric discharge preventing means, by using even a plastic package without provision of any electric discharge destruction measure it is possible to prevent destruction of the interdigital transducers by charge generated due to polarization at the time of mounting on SAW filter substrate or testing.

In addition, the package for accommodating the SAW filter has the structure having a terminal member extending out of it and also extending into it such as to form an L-shaped portion, it is possible to accommodate the SAW filter in the package such that the back surface of the chip substrate is in contact with the L-shaped

metal portion. Consequently, charge generated due to polarization can be neutralized without being concentrated on the front surface of the chip substrate of the SAW filter.

5           Furthermore, the SAW filter device according to the invention has the structure, in which the SAW filter with the electric discharge preventing means provided on the chip substrate is accommodated in the package of the structure having the terminal member extending out of  
10 the package and also extending into the same such as to form the L-shaped portion, the back surface of the chip substrate is in contact with the L-shaped metal portion inside the SAW filter device. Thus, charge generated, if any, due to polarization can be neutralized without  
15 being concentrated on the front surface of the chip substrate of the SAW filter.

Changes in construction will occur to those skilled in the art and various apparently different modifications and embodiments may be made without  
20 departing from the scope of the present invention. The matter set forth in the foregoing description and accompanying drawings is offered by way of illustration only. It is therefore intended that the foregoing description be regarded as illustrative rather than  
25 limiting.